Natural resources and livelihood concepts in monitoring rural development in Madagascar : issues of measurement and interpretation

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Abstract

Development can be seen as an asset portfolio management process, be it at national or household level. In Madagascar, there is a network of rural observatories which, for several years, has monitored numerous households in a number of different regions. To ensure a solid analytical base, the livelihoods conceptual framework is used in an attempt to quantify household strategies relating to the accumulation of capital and the diversification of incomes. A particularly dynamic region was chosen (Lake Alaotra). Among the 252 households monitored over a period of seven years, three main types of livelihood asset management trajectory were identified and associated with six types of income diversification trajectory. Identifying the asset trajectories proved most problematic, requiring work on the indicators and an increased use of surveys.

Key words: farm households, welfare and poverty, temporal analysis

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I. Introduction

In a recent publication, the World Bank asked "Where is the wealth of Nations?". This reference book highlighted with cross-country comparisons the importance of natural capital in the development of some poor nations (Hamilton and World Bank, 2006). Madagascar is recognized as one of these poorest countries, which is nevertheless richly endowed with a wide range of natural resources. The analyses conducted are convincing and inspired the present study which aims at transposing them to the microeconomic level of households.

At this level, the issues of identification and measurement of what natural capital is, and how they could be compared to other types of capital are not exactly the same as at the national level. Furthermore, connecting asset levels to livelihood strategies and income levels requires specific methods. These facts led us to adopt the livelihood conceptual framework, which was implemented using a rural household database[1], in order to provide tools for panel data analysis to the information system and to present accessible results for decision-makers and all actors involved in rural development.

In the literature, there are numerous references to poor rural or agricultural households and their livelihoods. The most comprehensive presentation of the livelihood conceptual framework appears in the summary and advisory work of the Department for International Development of the British Government (DFID), with the support of academics and researchers who contributed to developing and promoting this framework (Department for International Development, 2001). As explained in this document: "A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource

[1] The « Réseau des Observatoires Ruraux » (ROR) is an illustrative information system which conducted surveys on households for several years in some rural sites of Madagascar. Alaotra is the studied site, for which data was collected with the support of the Agence Française de Développement (AFD).

base." (Department for International Development, 2001; Robert Chambers and Conway, 1992; R. Chambers, 1995; Ellis, 1998; Scoones, 2009; Bebbington, 1999).

If we consider the microeconomic sphere of households, the conceptual framework summarized in Appendix 1 is focused on the identification of their livelihood assets. Five main types of asset are presented: human capital, social capital, natural capital, physical and financial capital. Each capital comprises various components that are difficult to measure and aggregate. Indeed, capital measurement is crucial but encounters methodological limits both on the macro level (Aglietta, 2011) and micro level, particularly in the fields of development economics (Alkire, 2011).

For natural capital specifically, research found some contradictions on its correlations with poverty trends, especially with income levels. The World Bank showed that it contributes for 33% of Madagascar's wealth stocks in 2000 and that the value of natural capital per capita rises with income when other studies argue that development entails the depletion of natural capital (Hamilton and World Bank, 2006).

Thus, this study attempt to identify livelihood strategies implemented by households either by analyzing the evolution of their "livelihood asset" portfolio and by analyzing the evolution of their activity and income portfolio. The underpinning hypothesis is that correspondences exist between the dynamics of these two portfolios given the constraints of exogenous shocks and the local dynamics in the light of national context.

Once we have explained the measurement and analysis methods adopted for the studied site, we present the typical trajectories followed by the households with regard to their livelihood assets. For these same households, we also identify typical trajectories of activity and income. By comparing and associating these two sets of trajectories, we attempt to highlight their correspondences and illustrate obvious coherent strategies.

II. Data and methods

A. Data

The household analysis is based on longitudinal socio-economic data covering seven successive year (2000 to 2006) in the Alaotra site. A panel data is created using the annual socio-economic surveys conducted by the ROR. The Alaotra site is part of the Alaotra Mangoro Region where the rural poverty ratio is of 56%. With a national poverty ratio of

71%, this Region is on average one of the richest Regions in the country[2] (behind the Analamanga Region which includes the capital city) (Institut National de la Statistique, 2011a).

The surveys are conducted in some villages selected to provide a quite exhaustive vision of community life. A sample of 500 households are surveyed every year and a significant part of the sample is kept every year - with inevitable adjustments and renewal. Over the period from 2000 to 2006, 252 households were surveyed on a permanent basis in the Alaotra site.

These annual surveys are retrospective and concern household characteristics, the activities of its members, all farm productions, household's food security and its asset endowment. The database also permits income computation.

Policy and regional programming documents, value chain studies and national statistics are used to specify the vulnerability context as well as the main structures and processes observed in the site. This context analysis is useful to complete the livelihood framework (cf. Appendix 1.

B. Data processing

1. Calculating the livelihood assets indicators

We adopted the five standard categories of livelihood assets: human capital, social capital, natural capital, physical and financial capital (cf. Appendix 1). Each of these assets is measured using a set of 2 to 7 variables extracted from the survey database. These variables are listed in Appendix 2. In order to differentiate households on their livelihood assets, we computed asset scores. The score is obtained by (i) conducting an hierarchical clustering from the variables for each category of capital and for each household in the sample to get asset clusters then (ii) conducting a correspondence analysis followed by another hierarchical clustering to get 3 livelihood asset profiles (cf.

Graph 1).

[2] Madagascar is divided into 22 Regions.

In the literature, the combinations of the five categories of livelihood assets are represented as a pentagon. The scores are adequate to illustrate these five components in "radar"-type graphs. Difference tests are also conducted to clarify the diversity between the livelihood asset profiles.

2. Identifying asset trajectories

For each household, we have 7 annual value which enable us to define a trajectory. In order to identify a limited but statistically relevant number of typical trajectories, the hierarchical clustering method is implemented on panel data: this method allows each household to be connected to a specific typical trajectory. Three (3) typical asset trajectories are found in the sample.

Identifying portfolio management strategies

A similar method as for the assets is used for income components in order to identify strategies of income portfolio management. The difference is that we have a single metric (the local currency: MGA[3]) for all income components. The income sources were aggregated into five categories: farm income, agricultural wages, non-agricultural wages, income from natural resources (mainly fishing, hunting, gathering, logging and mining) and other sources. In order to eliminate the effects of monetary inflation, all incomes were corrected using an index available at a national level (Institut National de la Statistique, 2011b). Six (6) typical income trajectories (A, B, C, D, E, F) are found in the sample.

3. Pairing livelihood asset and income trajectories

The relationships between livelihood asset and income trajectories are explored using a multinomial logit analysis. Concurrently, a probit regression is conducted on panel data in order to weigh the effect of asset endowment on the probability of each option (A, B, C, D, E, F) compared to all the other options. From these analyses, we get the trends on positive or negative influence of each category of livelihood asset on every income trajectory.

III. Results and discussions

A. Alaotra: a dynamic context in a uncertain environment

[3] MGA=Ariary is the Malagasy local currency. 1 MGA=

The Alaotra Mangoro Region enjoys a privileged situation as the leading rice granary of Madagascar. This area has benefitted from the implementation of large scale irrigation projects since the 1950s. Lately, these colonial or public interventions have continued with actions aiming at supporting rice production in order to achieve the national food security goals[4]. Over the studied period, the Region therefore benefitted from the implementation of "Green Revolution"-like projects concerning mechanization, maintenance and protection of irrigation infrastructures, dissemination of sustainable intensive techniques and various other soft programs such as farmers'organisation's empowerment. As the leading rice granary, the Region is also one of the largest agricultural employment basins at the country level.

However, the area remains exposed to some natural shocks such as drought (in 2003 and 2006) or hurricanes and flood (in 2004 and 2007) even if these shocks are partly offset by irrigation infrastructures. An important economic shock also occurred in the studied period: the national rice crisis in 2004-2005 due to the conjunction of climatic hazards and international context of global markets, resulting in the doubling of rice prices (Razafimandimby and Dabat, 2006). In addition, the Region is characterized by the slight, rather ambiguous frontlines between (i) the large areas for intensive agriculture; (ii) conservation areas with high endemicity of plants and animals and (iii) recent and older mining areas (chromium, gold, gems). Though, local people have access to direct opportunities from continental fishing, gathering (eg. fiber for local handcrafts), hunting and the collection of wood fire or timber. The most common natural capital they make use of – mainly for agricultural production – are land, water through irrigation and the capacity to produce a wide variety of crops given the type of soil, the localization of the plot and the microclimatic conditions. The average area for rice plots is of 0.8 hectares but quite 25% of the sampled households does not cultivate their own rice plots while 15% among the better-off own more than 2 hectares.

B. Differentiating livelihood assets

1. Three main livelihood asset profiles

Graph 1 illustrates the three main statistically identifiable asset profiles over the studied period. The groups are ordered by the number of occurrences in the period from 2000 to 2006.

[4] Rice is the most common staple food for Malagasy people. The country is internationally ranked in the top-10 for rice consumption per capita.

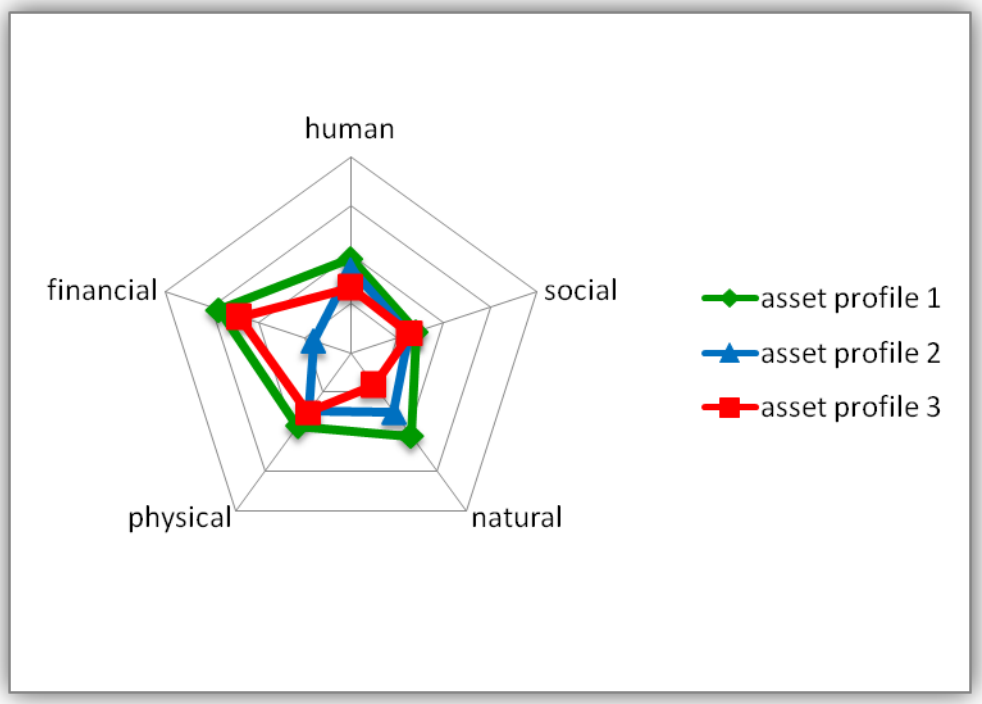
The first group (asset profile #1) can be distinguished by a greater endowment than the other groups for all five components of capital. This group accounts for 45% of the cases and could be described as relatively well-off.

The second group (asset profile #2) accounts for 36% of the cases and differs from the asset profile #1 in that it has less natural capital and much more limited financial capital.

The third group (asset profile #3) accounts for 19% of the cases. The group members enjoy more limited human capital and less natural capital than the two other groups, but a better financial situation than asset profile #2.

This static illustration confirms the importance of taking into account the different forms of capital enjoyed by agricultural households. It does not, however, tell us anything about the strategies implemented by these households. A dynamic approach is required and can be applied in terms of trajectories.

Graph 1: Livelihood asset profiles (2000-2006)



Source : authors, based on Alaotra panel data (2000-2006)

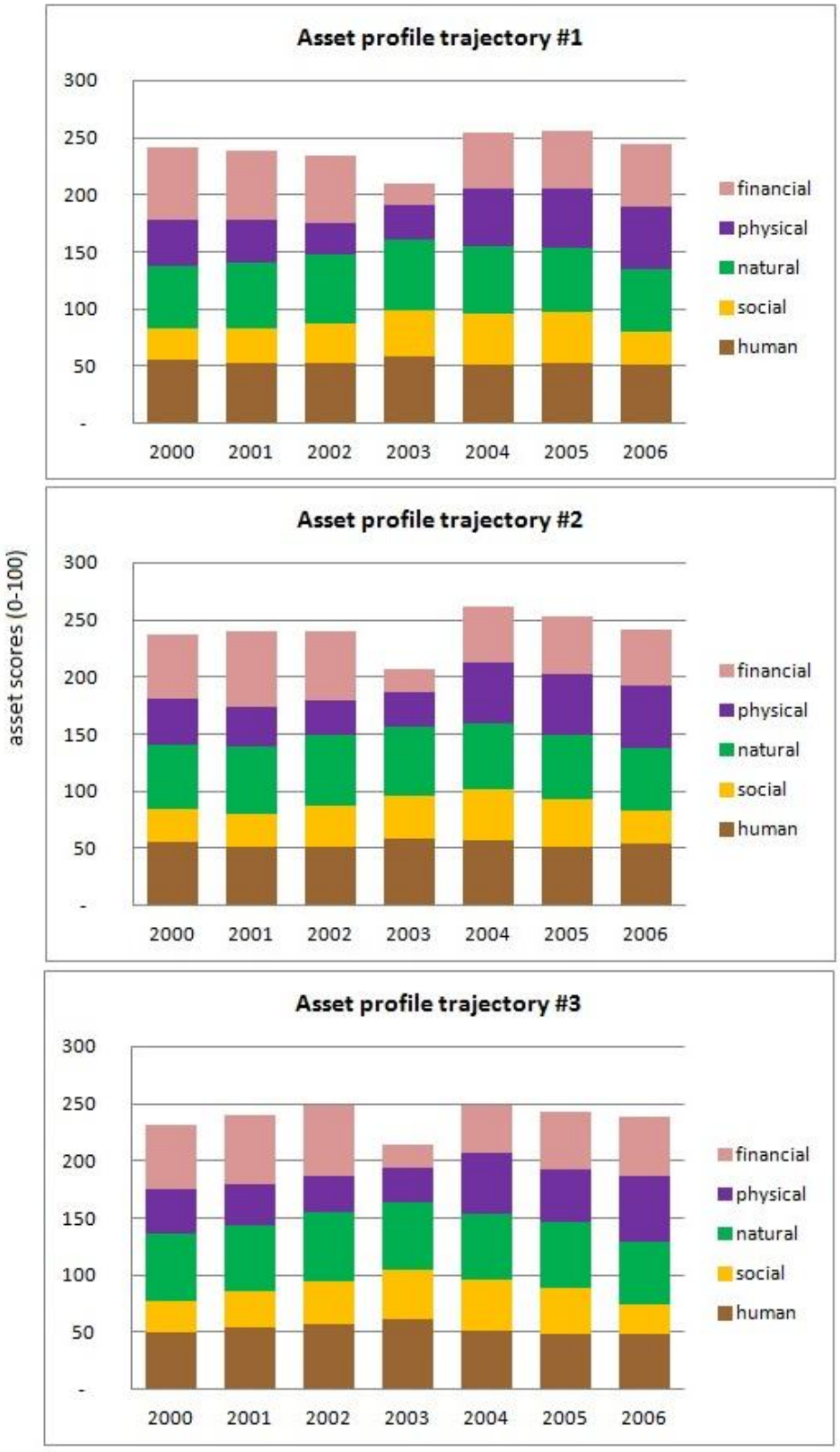
2. Capitalization trajectories which are difficult to qualify

The statistical analysis of the evolution of the five asset categories divided the households into three new groups (1,2,3) according to the method presented above and explained in details in Appendix 3.

Graph 2 illustrate the asset portfolio evolution for each group of asset trajectory. The average scores of assets and their inter-class variances are not significantly different. However, inter-annual trends are noticed for all groups that could be hypothetically associated to structural context and shocks related in § II.A.

Indeed, it appears that climatic shocks in 2003 have induced a general reduction in capital levels for all groups of asset trajectories, while there is some improvement since 2004 especially for physical capital (mechanization subsidies, improved living conditions of the largest producers in response to rising prices of rice, etc.). Financial capital can also progress through the evolution of such savings capacity or contraction of credit. A trend in human capital may reflect, meanwhile, situations of migration or demographic shocks. Natural capital appears, however, stable over the period of 7 years but does not exclude the existence of situations of substitutions within the category.

Graph 2: Evolution of the 3 groups of asset trajectories



Source : authors, based on Alaotra panel data (2000-2006)

C. Income portfolio management strategies

1. Components of income

Five main income components were established to illustrate the diversity of household activities:

- Farm income: income from agriculture and breeding, including self-consumption
- Agricultural wages: from working as seasonal or permanent worker for other farms and fields
- Non-agricultural wages: from skilled and unskilled labour in the non-agricultural public and private sectors
- Use of natural resources: fishing, hunting, gathering, mining, logging and use of common forestry resources
- Other income: income from other independent activities, received transfers and subsidies.

2. Characteristic diversification trajectories

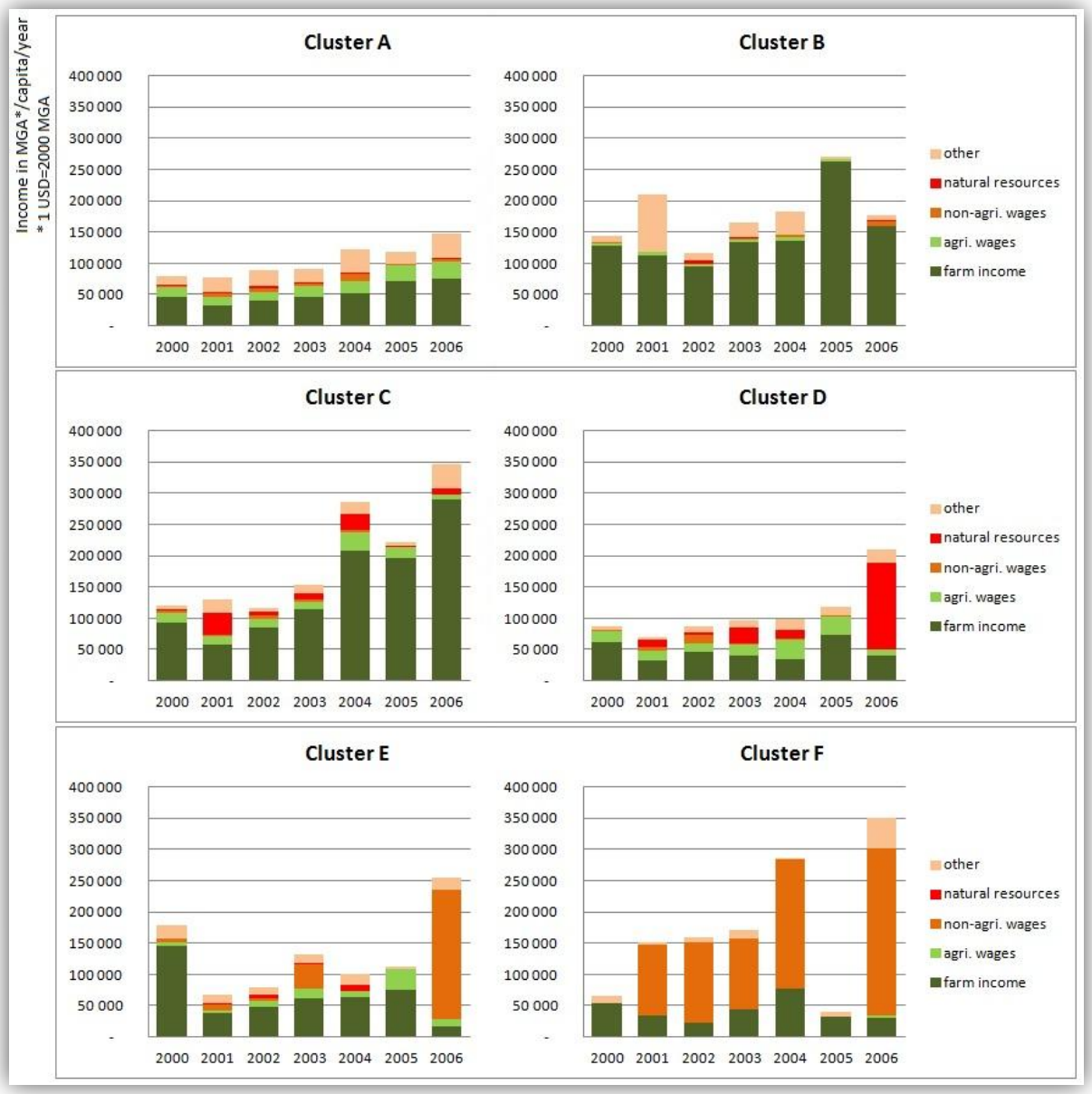
Data analysis highlighted six income trajectory clusters, three of which account for more than 90% of the sampled households. The details of these clusters and the yer-to-year evolution of their components are presented in Appendix 3.

Table 1: Clusters of income trajectories

Cluster	Description	% of the sample
A	Low and diversified incomes, increasing slightly	68
B	Medium incomes based on agriculture with various additions	15
C	Medium incomes based on agriculture, increasing quickly, diversified including **the use of natural resources**	8
D	Low and diversified incomes with **increasing use of natural resources**	4
E	Low to medium incomes, diversified trhough move towards non-agricultural wages in 2006	3
F	Low incomes increasing quickly with non-agricultural wages, but unstable	2

Source: authors

Graph 3: Evolution of the income portfolio for the 6 income trajectory clusters



Source: authors, based of Alaotra database (2000-2006)

The vast majority of household's livelihoods lie primarily on agriculture : the incomes of the households belonging to cluster B and C relies on average at respectively 81% and 76% on farm income. The households of the cluster F are the most independent from farm income with 24% of their income on average. Farming is a sector in which incomes can increase quite significantly for some households, for instance for those in cluster C since the years 2003-2004. This situation can be related to rice crisis that privileged farmers with high rice production (bigger farmsize), such as households in cluster B or C. this fact leads to expect for a relationship between available farmland as a natural capital and income. On the other

hand, some households with limited farm income such as A, D, E, F seem to improve their situation either by reinforcing agricultural wages (clusters A and D in 2004) or on the odd occasion, non-agricultural wages (cluster F in 2004). We also observe some years when households switch with incomes from the use of natural resources (cluster C in 2001 and 2004 and cluster D in 2003 and 2006), mainly when farm income is low.

Are these livelihood strategies dependent on specific livelihood assets?

D. Exploring relationships between income trajectories and livelihood assets

We detected that while a vast majority of households evolve very little (cluster A), some others instigate selective extension of their activities with wage-earning activities or the use of natural resources. The following analysis checks for relationships between these income portfolio management strategies and asset endowments. The detailed results of the multinomial logit are presented in Appendix 4.

Table 2: Summary of the results of the multinomial logit regression

Cluster	Description of income portfolio strategies	Livelihood assets				
		Human	**Social**	**Natural**	**Physical**	**Financial**
B	Medium incomes based on agriculture with various additions	+	-	+++	+++	+
C	Medium incomes based on agriculture, increasing quickly, diversified including **the use of natural resources**	+			+	+
D	Low and diversified incomes with **increasing use of natural resources**			---		
E	Low to medium incomes, diversified through move towards non-agricultural wages in 2006	+	+	+++		
F	Low incomes increasing quickly with non-agricultural wages, but unstable	+				+

Reference for multinomial logit regression : Cluster A

+ *asset with positive influence*

- *asset with negative influence*

Source: authors

Plus and minus signs are repeated thrice (+++ or ---) if the results of the multinomial logit regression is corroborated by the probit regression on panel data.

The analysis demonstrates that any household has more chance to join cluster B (with increasing farm incomes) if they are better endowed with different assets, except for social

capital. Of the 5 livelihood assets, natural capital has the greatest importance thereby confirming the role of land and its specifications (irrigation, capacity for crop diversification) to ensure the sustainability of livelihoods relying on farm activities. The situation of households in cluster C is quite similar to that of cluster B with the weight of physical, human and financial capital but without the effect of natural capital. This observation can be associated with the results for cluster D, where a low level of natural capital increases the probability of resorting to the use of natural resources in order to generate income. On the other hand, a higher level of social capital would tend to induce a shift towards a greater contribution on non-agricultural wages (cluster E) and inversely (cluster B).

IV. Conclusion

"If development is approached as a process of portfolio management" (ref World Bank): the quantitative explanation of this process is not a clear-cut matter in terms of assets. Even in a relatively dynamic context, household's accumulation/subtitution strategies are difficult to detangle. First of all, a large number of observations is required over many years.

Second, the aggregation of indices on livelihood assets faces pitfalls of choice and weighting and measurement methods requires wider studies as researches on development indicators (ref Deaton). Quantitative analysis could also be enriched with more participatory approach such as those presented in Ellis and Freeman'comparison of four African countries (ref Ellis and Freeman 2004).

Though, the much clearer results obtained for income portfolio trajectories and management strategies confirm the efficiency of the statistical methods used for dynamic analysis on household panel data. In addition, the results relating to the associations between livelihood assets and income diversification emphasizes the importance of natural capital in farm-oriented livelihood strategies. In contrast, households with low or declining levels of natural capital tend to fulfill their income from common natural resources through fishing, gathering, hunting, logging or mining.

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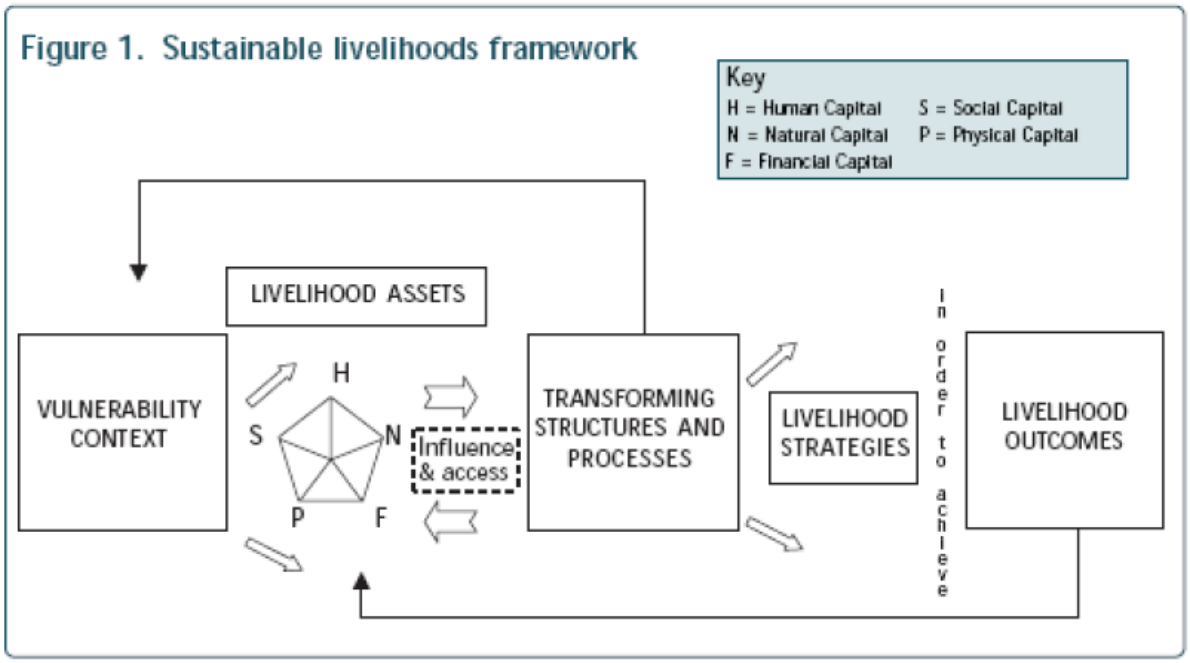
Appendices

Appendix 1: Sustainable livelihoods framework



Source: DFID (2001)

Appendix 2: Asset decomposition and aggregations

Capital	variable	units	mean	standard deviation	median	cv	Méthodo	Trajectories		%	Synthesis	Clusters of assets trajectories
Human capital	Size of the household	nb. of members	5,4	2,03	5	0,38	∑ /year--> CAH	3	hum1	20,6	AFCM --> CAH	3 clusters cl_cap1=81 cl_cap2=102 cl_cap3=69
	Dependency ratio	dependent persons /labor force	1,18	0,87	1	0,74			hum2	50,0		
	Sex ratio	male / female	1,33	1,13	1	0,85			hum3	29,4		
	Nb. of literate adults	nb.	2,78	1,56	2	0,56						
Social capital	Expenses for mutual aid in rice cultivation	000 MGA/HH/year	2 060	7 112	0	3,45	∑ /year--> CAH	4	soc1	37,7		
	Expenses for mutual aid in other crops cultivation	000 MGA/HH/year	156	1 078	0	6,92			soc2	21,8		
	HH receiving transfers	%	33%		0%				soc3	22,2		
	HH sending transfers	%	14%		0%				soc4	18,3		
Natural capital	Area of rice fields	ares	61	108	20	1,76	∑ /year --> CAH	3	nat1	46,8		
	Nb. of crops	nb.	4,43	2,73	4	0,61			nat2	31,3		
	% of irrigated rice fields	%	85%	32%	100%	38%			nat3	21,8		
Physical capital	Cattle	nb.	2,26		0	2,92	∑ /year--> CAH	3	phy1	25,4		
	HH owning bicycle	%	19%		0%	2,04			phy2	25,4		
	HH owning radio	%	49%		0%	1,01			phy3	49,2		
	HH owning TV	%	2%		0%	6,4						
	HH owning phone	%	0%		0%	42						
	HH having access to water	%	60%		100%	0,82						
	HH having access to sanitation	%	40%		0%	1,21						
Financial capital	HH with saving	%	60%		100%	0,82	∑ /year--> CAH	3	fin1	56,7		
									fin2	34,5		
	HH having access to credit	%	16%		0%	2,29			fin3	8,7		

Appendix 3: Evolution of income portfolio per income trajectory cluster

income cluster	income component	2000	2001	2002	2003	2004	2005	2006	% mean contribution
A	farm income	47	33	41	47	52	72	75	**50%**
	ag. wages	14	14	14	16	20	24	28	**18%**
	non-agr. wages	3	5	5	5	11	2	3	**5%**
	natural res.	1	2	3	1	2	0	2	**2%**
	other sources	15	23	25	22	38	19	40	**25%**
		80	***77***	***89***	***92***	***123***	***118***	***148***	**100%**
B	farm income	128	112	94	135	137	262	159	**81%**
	ag. wages	3	5	5	3	4	4	1	**2%**
	non-agr. wages	2	0	1	2	4	-	7	**1%**
	natural res.	0	1	5	1	0	-	1	**1%**
	other sources	9	90	12	24	38	4	9	**15%**
		143	***209***	***117***	***165***	***183***	***270***	***177***	**100%**
C	farm income	92	59	85	113	208	196	289	**76%**
	ag. wages	16	12	14	14	28	19	8	**8%**
	non-agr. wages	5	3	6	3	5	-	-	**2%**
	natural res.	2	36	6	11	25	2	10	**7%**
	other sources	5	20	6	14	19	5	39	**8%**
		121	***130***	***117***	***154***	***286***	***221***	***346***	**100%**
D	farm income	61	32	46	40	34	73	40	**42%**
	ag. wages	19	16	15	17	32	31	10	**18%**
	non-agr. wages	0	5	13	3	1	2	-	**3%**
	natural res.	-	12	3	26	14	-	139	**25%**
	other sources	7	5	11	11	18	13	20	**11%**
		88	***69***	***87***	***97***	***99***	***118***	***209***	**100%**
E	farm income	145	38	48	62	63	76	17	**48%**
	ag. wages	7	5	11	15	10	32	12	**10%**
	non-agr. wages	5	9	4	39	-	-	206	**28%**
	natural res.	-	1	5	2	10	-	-	**2%**
	other sources	21	15	11	15	18	5	20	**11%**
		178	***68***	***79***	***133***	***102***	***113***	***254***	**100%**
F	farm income	55	33	23	43	78	32	30	**24%**
	ag. wages	-	-	-	1	-	-	5	**0%**
	non-agr. wages	-	115	129	113	207	-	267	**68%**
	natural res.	-	-	-	-	-	-	-	**0%**
	other sources	11	2	8	13	0	9	49	**8%**
		66	***151***	***160***	***170***	***285***	***41***	***350***	**100%**

Appendix 4 : Results for multinomial logit analysis

Variables	B	C	D	E	F
Human capital	0.014 **	0.013 *	0.019	0.022 *	0.052 ***
	(0.006)	(0.007)	(0.012)	(0.011)	(0.020)
Social capital	-0.006 *	-0.000	0.015	0.019 *	0.015
	(0.006)	(0.009)	(0.010)	(0.010)	(0.016)
Natural capital	0.069 ***	-0.019	-0.043 ***	0.109 ***	0.009
	(0.013)	(0.017)	(0.015)	(0.030)	(0.024)
Physical capital	0.041 ***	0.019 **	-0.015	0.001	0.006
	(0.006)	(0.009)	(0.012)	(0.013)	(0.018)
Financial capital	0.007 *	0.016 ***	0.005	0.007	0.021 **
	(0.004)	(0.006)	(0.008)	(0.009)	(0.010)
Constant	-7.630 ***	-3.243 ***	-1.243	-11.748 ***	-9.126 ***
	(0.993)	(1.101)	(1.312)	(2.350)	(2.122)
Number of observations		619			
log pseudolikelihood		-704			
Pseudo R^2 (McFadden)		9.72			
Estrella		23.45			

Reference: cluster A

Standard errors in parenthesis

*Significance level: ***: 1%; **: 5%; *: 10%*

Appendix 5 : Probit regression

Variables	A	B	C	D	E	F
Human capital	-0.013	0.008	0.000	0.006	0.006	0.016
	(0.009)	(0.010)	(0.011)	(0.011)	(0.012)	(0.013)
Social capital	0.002	-0.011	-0.001	0.009	0.011	0.010
	(0.007)	(0.008)	(0.010)	(0.010)	(0.011)	(0.012)
Natural capital	-0.033 *	0.060 ***	-0.026	-0.041 *	0.040 *	-0.001
	(0.017)	(0.020)	(0.022)	(0.024)	(0.022)	(0.027)
Physical capital	-0.018 **	0.025 ***	0.008	-0.017	-0.007	-0.004
	(0.008)	(0.009)	(0.011)	(0.013)	(0.011)	(0.013)
Financial capital	-0.005	0.003	0.006	-0.000	0.001	0.008
	(0.006)	(0.006)	(0.008)	(0.007)	(0.011)	(0.009)
Constant	4.200	-7.152 ***	-2.693	-1.101	0.001	-5.075
	(1.269)	(1.447)	(1.609)	(1.609)	(0.007)	(2.040)
Nb. of obs.	626	626	626	626	626	626
Log likelihood	-181	-134	-86	-56	-47	-29

Standard errors in parenthesis

*Significance level: ***: 1%; **: 5%; *: 10%*